Optimising baby development

Current research

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Raison d’être

Why do we need to optimise babies development? Surely in today’s modern world our babies and children have every opportunity possible to develop well?

Surprisingly the statistics tell us a different story.

Dr Jane Williams. 2015.
Raison d’être

• In many developed countries across the world, up to 30% of 5 year olds are developmentally “at risk” in their physical health, social competence & emotional maturity ...(i.e. AEDI, 2012)

• Australia, USA, UK, Canada, Ireland are all concerned .. And its across all SES groups (Shonkoff & Phillips, 2000; Cowley, 2015)

• This is reflected in how well children learn at school.

• Children who are assessed as being “at risk” or “vulnerable” in development are most likely the children who will have literacy and numeracy challenges throughout their primary school years (Brinkman et al. 2013) ... and into adult life - education levels, income and success (Shonkoff & Phillips, 2000)
Why is this happening?

- There has been growing world-wide interest in early childhood years for the past 14 years, mostly in response to these disastrous (and growing) figures of children with learning and behavioural challenges at school (Shonkoff & Phillips, 2000; McCain, Mustard & Shanker, 2007)
.. And how does this relate to first years of life?

- **There has now been demonstrated a very clear relationship** between the experiences a child has in their early years and how successfully that child will perform socially, emotionally, and academically in later life (Shonkoff & Phillips, 2000).

- The experiences we have in early life play a crucial role in coordinating the timing and pattern of gene expression, which in turns determines brain architecture (Fox, Levitt & Nelson, 2010).

- Research on animal studies show that environmental factors and experiences in early life can permanently alter the genome of an individual through chemical modification - and this will impact on long term cognitive and social-emotional functioning (Szyf, McGowan & Meany, 2008).
Brain development

- We are born with literally billions of brain cells. At birth, babies have approximately the same number of neurons as an adult but approximately 10 times fewer connections (Lexmond & Reeves, 2009)

Brain facts:

- 86 billion nerves in the brain
- 16 billion in the cortex
- 70 billion neurons in the cerebellum
- 100 - 500 trillion synapses
- $10^{150}$ synaptic links in the brain!

- As we experience the world, those brain cells interact & form complex connections - by 4 years of the age the brain has 90% of its connections in place (Lexmond & Reeves, 2009)
Brain development

• In the beginning there is too much of everything. 40% of neurons are eliminated before birth (Williams & Rakic, 2004), then at birth networks are set up in response to the environment

• ‘Pruning’ occurs from 12 months to puberty, based on usage (Chechik, Meilijson & Ruppin, 1999)

• What remains is ‘what the brain needs in this environment’ (Neubauer & Hublin, 2012)

Brain development

• Between birth and about age three, children’s brains are more responsive to stimulation - because they are more receptive to new information - than they will be at any other stage in life (Lex mond & Reeves, 2009)

• Certain parts of the brain are highly responsive, or sensitive, to certain experiences at birth and in the first years. (McCain, Mustard & Shanker, 2007)
Brain development: sensitive periods

`Sensitive periods’ in early brain development

Graph developed by Council for Early Child Development (ref: Nash, 1997; Early Years Study, 1999; Shonkoff, 2000.)
Brain development

• “High level neural circuits that carry out sophisticated mental functions depend on the quality of the information that is provided to them by lower level circuits. Low level circuits whose architecture is shaped by healthy experiences early in life provide high level circuits with precise, high quality information”  (Fox, Levitt & Nelson, 2010, p. 35)
Higher level development builds on lower level development (Knudsen, 2004).

Higher level adaptation is more difficult if lower level has been compromised – ‘skill begets skill’ (Perry, 2000).
Brain development

• Babies and young children need the correct stimulation at the right time to provide the platform on which executive function - higher complex thinking and learning and emotional regulation skills - is based (Perry, 2000: Diamond, 2013)

• Many babies and small children are not receiving the necessary stimulation. Why Not?
Reasons for “missed opportunities”

- Natural experiences for brain development are decreased because of modern society
  - A time poor world - less moments of interaction and one-on-one care
  - Fear of SIDS - “Back to Sleep” campaign reduced time on tummy and sensory experiences for babies.
  - “Bubble wrapped” babies
  - Not as much play space for children to play nor moving play equipment
  - Not as safe for our children to play outside
  - Much more TV, computers and “sit down” time
  - Much more driving, less walking, running, skipping
  - “Containers”.
  - Dietary changes. Lack of knowledge . Social disadvantage.
Early prevention = economic gains

Graph: Rate of return on investment in human capital (Heckman, 2006)
Early prevention = lifetime gains

- It's not only about the economics cost... it's about laying the neurological foundations for healthy development in ALL areas for an entire lifetime... children who have the right experiences in their early years:
  - Emotionally
  - Socially
  - Academically
  - Physically
  - Financially
  - In long term mental health
  - In long term physical health

(Shonkoff & Phillips, 2000; Moore, 2014)
Optimising healthy development in babies

- Endogenous Brain activity & Sleep
- Social/Emotional
  - Loving attention
  - Low stress
  - Communication
- Sensory stimulation
- Motor experiences
- Chemical
  - Nutrition
  - Environmental
- Genetics & Epigenetics

Dr. Jane Williams, 2015.
Genetics & Epigenetics

Optimising brain development through epigenesis

• Environmental factors influence the structure of the epigenome - the gene ‘switch’ which enables chemical messengers to ‘turn the gene expression on or off’ (Zhang, T-Y. & Meaney, M., 2010)

• Negative childhood experiences can create biochemical barriers which attach to genetic switch and prevent ‘messengers from landing’ - so epigenetic action cannot occur (Lovic, 2010)

• High stress has been shown to inhibit the anti-stress gene from activating (Weaver et al. 2004).
Social/Emotional: love

- Optimising brain development: love & attention
  - Positive relationships have a positive affect on child’s overall development (& genetic expression)
  - Early relationships drive the development of optimal neural pathways (McCain, Mustard & Shanker, 2007, p. 18)
- Negative experiences affect brain development just as much as positive experiences affect brain development (Nelson et al., 2007; Lovic, 2004)
Social/Emotional: stress

Optimising brain development: low stress

• High Stress environments:
  • increase cortisol levels in blood affecting brain development, emotional control and behaviour (Lupien et al., 2009)
  • affect what brain connections are made and become the primary route for response (Nelson et al., 2007)

• No-stress environments are also detrimental.
  • Children do not learn to regulate their emotions (Lovic 2010)
Social/Emotional: exploration

- **Bonding System** + **Exploration system** (autonomy and ‘need to discover’)

Over-protected, no stress, little autonomy = patience
- emotional regulation
- motor maturity
- (prefrontal cortex immaturity)

Not protected, too much stress, too much autonomy =
- patience
- executive function
- emotional regulation
- motor maturity
- cognition

(Lovic, 2010)
Social/Emotional: communication

• **Optimising brain development through communication**
  
  • Babies learn through mimicking, or ‘serve & return’ (Kuhl & Rivera-Gaxiola, 2008; Gopnik, Meltzoff & Kuhl, 2000).
  
  • They need a face that responds... not a computer generated image (Ward, Sundara, Conboy & Kuhl, 2009).
  
  • Reading regularly to babies improves language (Hardma & Jones, 1999)
  
  • Music, singing and rhythm is also highly stimulating. (Fonesca et al., 2011)
Optimising brain development through nutrition

• Babies born of mothers with less than optimal nutrition have higher burden of long term disease - cardiac, endocrine, neurological, cancer. Also shorter lifespan and earlier aging (Barker, 1997)
• Babies who are born small (< 2.7kg) often have compensatory growth in their early years- so they “catch up”... Barker’s finding suggest they have reduced length of their lifespan.
  • This occurs across all cultures.

• Infant nutrition is important for brain development.
  • Breast milk for first 6 months (WHO, 2014)
  • Omega 3 fatty acids, iron, calcium, zinc, iodine, Vit’s A,D,E & K, Vit’s C & B. (WHO, 2013)
Chemical: exogenous

- Optimising brain development: regulating environmental chemical uses.
- There has been an enormous increase in the amount of chemicals used over the past 50 years. ....and most of these chemicals are not tested on humans (Lichtenstieger, 2014)
- Correlations have been shown between exposure to chemicals and behaviours (Lichtenstieger, 2014)

Diagram:
- 1990: 400 m tonnes per year
- 1930: 1m tonnes per year
Chemicals: 2 examples

- Correlations between exposure to chemicals and behaviours

- Phthalates (measured in the urine of pregnant mums), if high levels, then found that 4 year old children have:
  - ↑ aggression
  - ↑ attention problems
  - ↑ conduct problems
  - ↑ depression
  - ↑ externalising problems
  - Boys are more heavily affected than girls. This study has been replicated in at least 7 other studies.

- Bisphenol A (measured in the urine of pregnant mums), if high levels, then found that 4 year old children have:
  - ↓ emotional control
  - ↓ inhibition
  - ↑ hyperactivity
  - ↑ anxiety
  - ↑ depression
  - Girls are more affected than boys.
  - Also found to affect hippocampus & memory in rats.
  - ?? Transgenerational affects - studies in mice (Lichtenstieger, 2014)
Endogenous: sleep

- Optimising brain development through sleep
  - Sleep and sleep cycles are essential for sensory system development in the fetus and young infant, as well as for preservation of brain plasticity and for creation of long-term memory and learning. (Penn & Shatz, 1999)
  - Sleep deprivation in the fetus and young infant has a profound effect on early sensory development and the creation of permanent neural circuits for the primary sensory systems (Graven, 2006)

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From: Graven & Brown (2008)
Sensory stimulation

- Touch
- Sight & Vision
- Hearing
- Taste & Smell
- Movement of joints & muscles
- Balance (vestibular sense)

Brain development
Sensory stimulation

- Optimising brain development through sensory stimulation
  - Early sensory experiences activates specific genes & different parts of the brain to differentiate functions and establish sensory pathways. (Wallace & Stein, 2007; Graven & Browne, 2008)
  - When more than one sense is stimulated at a time the brain benefits the most - the ‘firing & wiring’ occurs in more areas (Macaluso & Driver, 2005)
  - Repetition is important. “Consolidation and reconsolidation” creates long lasting and effective message pathways & memories. (Bauer, P. 2014)
Sensory stimulation

`Sensitive periods' in early brain development

Graph developed by Council for Early Child Development (ref: Nash, 1997; Early Years Study, 1999; Shonkoff, 2000.)
Sensory stimulation

- Sensory stimulation → sensory integration

- The long term aim (first 6 - 8 years) is for the brain to be able to integrate sensory information - receive, analyse and respond appropriately - a process called “sensory integration” (A. Jean Ayres, 1979)

- Movement is the primary medium through which sensory integration takes place (Koziol & Lutz, 2013)
Motor development

Optimising development through motor systems
• “The whole reason we have a brain and we think is because we move” (Barton, 2014)
• “Thinking is internalized movement” (Barton, 2014)
• Post-natal play correlates with brain growth (Montgomery 2014)
• Across species, brain size, and particularly postnatal brain growth, correlates with the amount of time spent actively playing” (Barton, 2014)
Motor development: The axle driving brain connectivity and complex cognition

(Image designed by Dr Jane Williams, KindyROO).
For optimal development babies need to experience the kind of stimulation that the brain has evolutionarily developed to expect: movement, sensory stimulation, good nutrition, freedom to explore, sleep and love are all important.

Movement is an oft forgotten key driver of healthy brain development - are babies into today's modern world getting enough?
References


References


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References


